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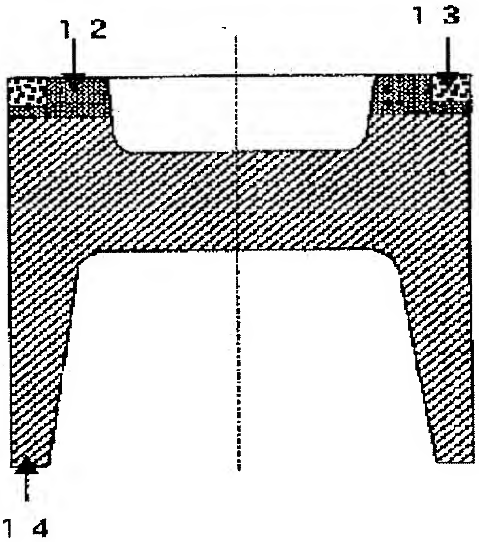
(54) METHOD OF COMPOSITE MOLDING FOR HIGH STRENGTH ALUMINUM ALLOY POWDER MATERIAL AND CASTING OF MOLTEN ALUMINUM ALLOY MATERIAL



(57)Abstract:

PROBLEM TO BE SOLVED: To solve the problem that, because the conventional aluminum alloy sliding and combustion system parts are manufactured by casting of molten material or partial cast-in insert of cast iron, the product manufactured by cast-in insert of cast iron is heavy in weight and inferior in joining strength with base material.

SOLUTION: A molten material of AC8A is cast, and the resultant casting is set in a mold. Subsequently, two kinds of aluminum alloy powders, having superfine grains and provided with required properties, are filled into the inside and outside peripheries, respectively. Then the powders are molded using a plasma discharge machine and simultaneously joined to the casting and integrally formed into one body as shown in figure 6. In the part in the figure 6, heat resistance is required of the upper inside periphery by reason of combustion and wear resistance is required of the outside periphery by reason of sliding, and further, weight reduction is needed for energy saving. Wear resistance is higher in a region 12 than in a region 14, aid a region 13 is composed of a powder material prepared by mixing a low friction material with the material of the region 12 and has excellent wear resistance. Because the aluminum alloys have superfine grains, they are reduced in weight, increased in strength, and excellent in formability and joining property to the base material, and thin- wall design is made possible.

[Claim(s)]

[Claim 1]The whole structure comprises two kinds of aluminum alloys like drawing 1, and 2 and 4, the upper -- 1, 3, and 7 -- a powder molding article -- lower -- 2, 4, and 8 comprise an ingot material cast -- lower -- a composite molding body having set 2, 4, and 8 after shaping and to a mold by casting, having been filled up with powder, and carrying out integral moulding to two-layer with hot forging (plasma discharge sintering ****).

[Claim 2]Like drawing 3, the whole structure comprises two kinds of aluminum alloys, and five outside the upper part A powder molding article structure, A composite molding body, wherein the lower part 6 comprised an ingot material cast, set 6 after shaping and to a mold by casting, filled up a periphery with powder and carries out integral moulding to two-layer with hot forging (plasma discharge sintering ****) in the upper part.

[Claim 3]The whole structure comprises three kinds of aluminum alloys like drawing 5 and 6, The outsides 10 and 13, inside, and the bottoms 9 and 12 comprise a powder molding article structure, and the lower parts 11 and 14 comprise an ingot material cast, lower -- setting 11 and 14 to a mold after shaping by casting -- powder -- lower -- a composite molding body characterized by carrying out integral moulding to three layers with hot forging (plasma discharge sintering ****) after having obtained and used 11 and 14 in a frame of a boundary after 1-mm restoration, dividing and filling up inside and outside two-layer and removing a frame.

[Claim 4]Claims 1 and 2, a composite molding body of three statements, wherein material of the upper part of drawing 4, drawing 3, 5, and 6 periphery is the material which mixed powder containing at least one ingredient of Mo, S, and C into material (drawing 3 is an inner peripheral material of 5 and 6) of inner circumference.

[Claim 5]As an ingredient of aluminum alloy powder of the upper part in which combustion arises and which requires an elevated-temperature heavy load, Claims 1 and 2 of Si, Fe, Ti, Cr, nickel, Co, Cu, and Zr which one or more sorts are consisted of and an intermetallic compound makes 40% not less than 15% by a use at least, aluminum-alloy-powder material of three statements.

[Claim 6]Claims 1, 2, and 3, aluminum alloy ingot material of four statements in which lower material is characterized by an intermetallic compound being the material at 20% or less whose specific gravity is lighter than claim 5 since load and temperature are lower than the upper part.

[Claim 7]When sintering (15 of drawing 7) of the part upper part, junction on lower parts (16 of drawing 7) or casting, and a forge molding material comrade join with a

plasma discharge sintering machine, the characteristic of material. Or when apprehensive [at the time of temperature up and application of pressure] about modification in shape of parts, In order to carry out temperature up to temperature which needs only sintering (15 of drawing 7) and a joined part efficiently and to maintain other portions (16 of drawing 7) to temperature which does not change, (**) Use a material metallic mold with thermal conductivity large [the other metallic mold (19 of drawing 7, 20)] in metallic mold material with large specific resistance, and specific resistance small [thermal conductivity is small, and] for a nearby metallic mold (17 of drawing 7, 18) sintered or joined.

(**) Temperature up or a nearby metallic mold to join makes capacity small by identical material or a dissimilar material, make temperature up easy to carry out, and other portions enlarge metallic mold capacity in order to lower temperature so that it may not change.

(**) (b) and (**) form and carry out the temperature control of the cooling system to heating apparatus, such as a heater, and the other metallic mold at a nearby metallic mold sintered and joined so that temperature may not go up.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention relates to the compound molding method of high intensity aluminum-alloy-powder material and an aluminum alloy ingot material cast.

[0002]

[Description of the Prior Art](b) The upper part where combustion temperature is high and the Power Reactor and Nuclear Fuel Development Corporation part structure whose temperature is 200-400 **, and which goes up has a near combustion part produces the heat-resistant reinforcing member which comprises Ni Resist cast iron to the different body with the main part, and carries out joint adherence of such a reinforcing member in the upper body which comprises an aluminum alloy by the method of friction welding. The cave for cooling is formed by blockading the circumferential groove provided in the upper part of the main part at this time by a reinforcing member. (For example, refer to JP,6-2613,B)

[0003]

[Problem(s) to be Solved by the Invention]Since the conventional elevated-temperature Power Reactor and Nuclear Fuel Development Corporation part structure constitutes the upper part from Ni Resist cast iron, as shown in Table 1,

its weight is heavy, and since it is Fe and nickel system material, the cooling efficiency of a top ring groove part is bad. The weak intermetallic compound which Fe contained in the joined part mostly is generated, and bonding strength is weak. Ni Resist cast iron has bad cutting ability compared with an aluminum alloy.

[Table 1]

	ニレジスト鋳鉄	アルミニウム合金粉末成形体
比重（g／ｃｍ2)	７．４	２．８～３．２
熱伝導率(W／ｍ・℃)	３２	８０～１４０

[0004]

[Means for Solving the Problem]In order to solve the above-mentioned problem and to reconcile (b) high intensity and high toughness, intensity and toughness are reconciled by volume rate control of an intermetallic compound like minuteness making of an organization by hyperquenching, and drawing 9 like drawing 8. Thereby, a light-gage weight saving becomes possible. By mixing low friction powder to the above-mentioned powder, and carrying out integral moulding of the periphery of a structure to it, it becomes impossible for an abrasion-resistant ring and alumite treatment to be needed, cost can be reduced, and a lead time can also be shortened.

[0005]

[Invention embodiment] This invention is with ARUMIUMU after-alloy-powder material in a part of structure, changes a powdered kind according to **** followed to a use, and a part, and fills up with and fabricates it to an aluminum alloy ingot material cast.

[0006]Since fatigue-at-elevated-temperature intensity is required for material of the above-mentioned elevated-temperature Power Reactor and Nuclear Fuel Development Corporation part upper part (a combustion part is near), not less than 15% of 40% or less of an intermetallic compound is desirable. A danger that it will become weak like drawing 9 if it becomes not less than 40%, and a crack will arise is high.

[0007]It is better to have quenched a crystal grain of the above-mentioned 0006 aluminum alloy materials from a field of intensity and a moldability to a powder generate time, and to make a crystal grain fine like drawing 8. Specifically, below the crystal grain 1 mu in which super-elasticity modification is possible is desirable.

[0008]As for powder material shaping of the above 0006-0007, it is desirable for elongation to maintain and fabricate to temperature which comes out most.

[0009]Since 0006 and low friction material of 0007 cause a fall of junction power like

[thing / strength reduction of material, and / which carries out up-and-down junction] drawing 10, they are desirable at a weight ratio. [30% or less of] since lower shape can be weak and it cannot change -- welding pressure -- 30 kg/mm2 or less -- temperature -- up-and-down material -- recrystallizing temperature (the 0.7th place of the melting point) with the lower melting point -- hot forging, diffused junction, or drawing 11 -- like -- discharge plasma sintering -- it is made to join Without changing other shape parts, in order that plasma may occur in a joining interface gap and may go up to it intensively [temperature] to an interface, since a way of plasma discharge sintering and junction can fabricate and join by low-pressure power, it is more desirable than hot forging and diffused junction.

[0010]The above-mentioned cementing material has that so good of Mg ** rare ****** which returns an oxide film of aluminum that a crystal grain is small. Specifically, 1micro or less which the crystal grain can super-elasticity transform, and 0.5 to 4% of Mg are desirable.

[0011]

[Example]When an example is described with reference to drawings, c of drawing 12 is 60 mm in outer diameter, 60 mm in height, and 250g in weight in the completed chart of a **** diesel piston. the piston upper part constitutes upper shape from 2 mm under a top ring groove with an aluminum-alloy-powder Plastic solid -- 1 mm of top ring groove backs -- by the way -- inner -- it is 31 and outside 34 -- a plane of composition to upper 1mm -- by the way, construction material is changed to 34. An inside 31 powder material component is aluminum(1-1) (**)+Si(20%)+Fe(9%)+Cu(3%)+Mg (1%), the outside (1-2) 34 is what mixed the powder of FeMoS 30% by the weight ratio to inside powder, and an average crystal grain is 1 micrometer. Since the reason for having used the above-mentioned material is in it like drawing 12 with super-particle powder [that high temperature strength is high (1-1)] since the high temperature strength in around 350 ** is required for the lip part 36, and the attachment-proof in around 300 ** is required for the top ring groove of 35, Like drawing 14, it was with the material which added the powder of FeMoS. Since FeMoS of the outside 34 could not join 1 mm of undersurfaces to the lower cast 32 easily, before FeMoS was included, it constituted from material of 31. since FeMoS specific gravity is heavy -- the minimum -- it limited to the required portion. Powdered use was minimized in order to lower cost, since a less or equal [since temperature and the load of this portion are low compared with 31 and 34, having made 32 into AC8A ingot material can secure intensity by AC8A material, and / a material cost] 1/3.(d) of drawing 12 provides a boundary for the powder which sets

the AC8A cast 32 to a mold with process drawing (1-1) after 1-mm restoration, fills up outside and inside with (1-2) and (1-1), and removes a boundary. It is made to join to the lower part 32 at the same time it sets a mold to the plasma discharge sintering machine of drawing 11 and fabricates top powder with the temperature of 470 ** by the pressure of 100MPa.

[0012]

[Effect of the Invention]This invention is carried out with a gestalt which was explained above, and does so an effect which is indicated below.

[0013]For the powder molding material of a detailed crystal grain, like drawing 13, from the conventional AC8A ingot material, since intensity is 2 to 5 times higher, a light-gage design is attained and a weight saving (ingot material cast top ratio) is made 30 to 60% with material and temperature.

[0014]Since the combustion chamber lip part 36 was conventionally made of large AC8A ingot material of a crystal grain in the drawing 12 **** diesel piston, the cracking crack arose at an around 350 ** elevated temperature for fatigue at elevated temperature, but. the detailed crystal grain which added high temperature components, such as Fe, like drawing 13, and generated the intermetallic compound about 30% -- since a powder compact, fatigue-at-elevated-temperature intensity is high, and there is no cracking crack.

[0015]Since the conventional diesel piston crestal plane part had joined the Ni Resist cast iron abrasion-resistant ring to the base material by friction welding, its intermetallic compound of a joined part is weak, and its bonding strength is weak. this invention article -- an aluminum containing alloy comrade's junction -- solid state welding (friction welding ****) -- a sake -- a joined part -- an intermetallic compound -- it can do -- hard -- bonding strength -- it is high . For the reason, shortening of top ring height is attained. (Shortening of top ring height has an effect in fuel consumption improvement)

[0016]By the use, the conventional gasoline piston carried out alumite treatment after working completion to the top ring groove, and has prevented seizure. Since this invention is fabricated with the powder which mixed FeMoS of low friction outside, its alumite treatment is unnecessary.

[Brief Description of the Drawings]

[Drawing 1]It is drawing of longitudinal section showing the compound molded body of claim 1.

[Drawing 2]It is drawing of longitudinal section showing the compound molded body of claim 1.

[Drawing 3]It is drawing of longitudinal section showing the compound molded body of claims 2 and 4.
[Drawing 4]It is drawing of longitudinal section showing the compound molded body of claims 1 and 4.
[Drawing 5]It is drawing of longitudinal section showing the compound molded body of claims 3 and 4.
[Drawing 6]It is drawing of longitudinal section showing the compound molded body of claims 3 and 4.
[Drawing 7]It is drawing of longitudinal section showing the molding method of claims 1-6.
[Drawing 8]It is a graph showing the tensile strength by aluminum alloy grain refining.
[Drawing 9]It is a related graph of the quantity of the intermetallic compound in aluminum alloy powder, and the toughness of a forge Plastic solid.
[Drawing 10]It is a related graph of the shearing stress of the mixed forge Plastic solid of aluminum alloy powder (aluminum-20Si-3Cu-1Mg-9Fe) and FeMoS powder, and the plasma discharge joined part of AC8A material.
[Drawing 11]It is a schematic diagram of plasma discharge junction.
[Drawing 12]a sets an AC8A cast to a mold with the figure showing internal-combustion engine piston rough ********** of claim 6, it is filled up with heat-resistant powder, b attaches a frame, and, in a heat resisting material and outside, the shape after processing and d of high-strain-rate-superplasticity processing and c are process drawings by after-restoration plasma discharge about ****** among them.
[Drawing 13]It is a related graph of the elevated-temperature tensile strength of an alloy Plastic solid in the end of AC8A ingot material and aluminum-20Si-3Cu-1Mg-9 Fe powder.
[Drawing 14]It is a related graph of the amount of FeMoS(s), and adhesion generation temperature in the agglutination examination of the forge Plastic solid which mixed the FeMoS after alloy powder of the aluminum-20Si-3Cu-1Mg-9 Fe alloy.
[Description of Notations]
1, 3, 9, 12 heat-resisting-aluminum-alloy powder compact
2, 4, 6, 8, 11, a 14 AC8A ingot material cast
13 The aluminum-alloy-powder Plastic solid excellent in the abrasion resistance which mixed low friction material to 1, 3, 9, and 12, and attachment-proof
15 Heat resisting aluminum alloy powder
16 Aluminum alloy ingot material cast
17 and 18 Metallic mold material with small thermal conductivity and large specific

resistance

19 and 20 Metallic mold material with thermal conductivity larger than 17 and 18 and the small Koyu resistance

21 Upper electrode

22 Upper punch

23 Mold

24 Sample

25 Lower punch

26 Vacuum chamber

27 Vacuum pump

28 Hydraulic power package

29 Pulse electrical energy

30 Thermal control system

31 Heat resisting aluminum alloy powder compact

32 AC8A ingot material piston lower molding by casting object

33 Metallic mold

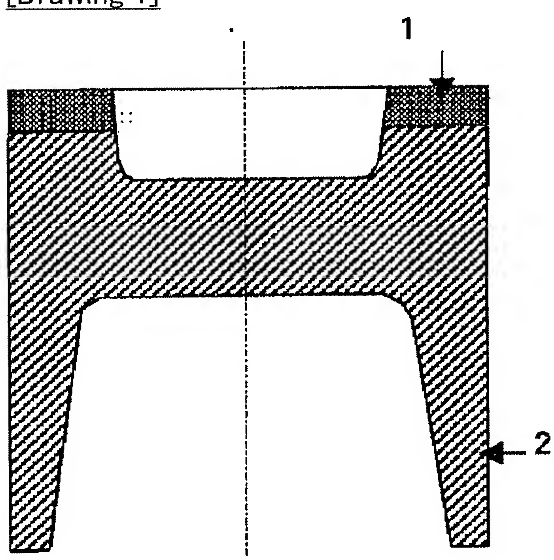
34 Powder material which carried out addition mixing of the FeMoS powder 30% at 29 materials

35 Direct injection diesel piston top ring groove

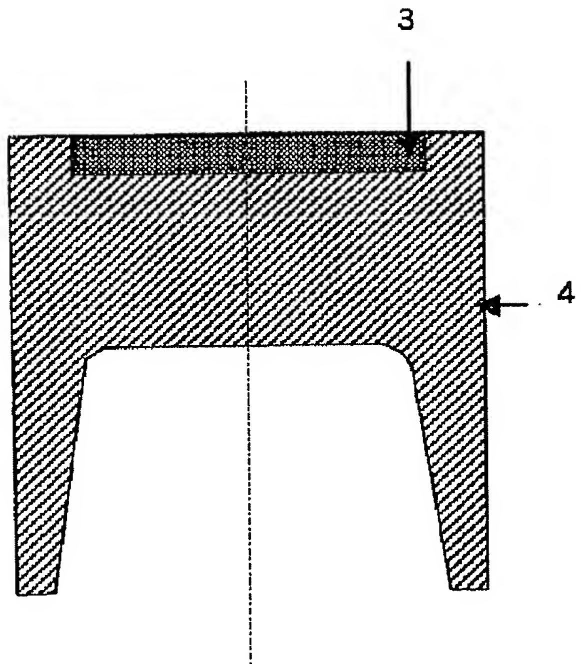
36 Direct injection diesel piston lip part

DRAWINGS

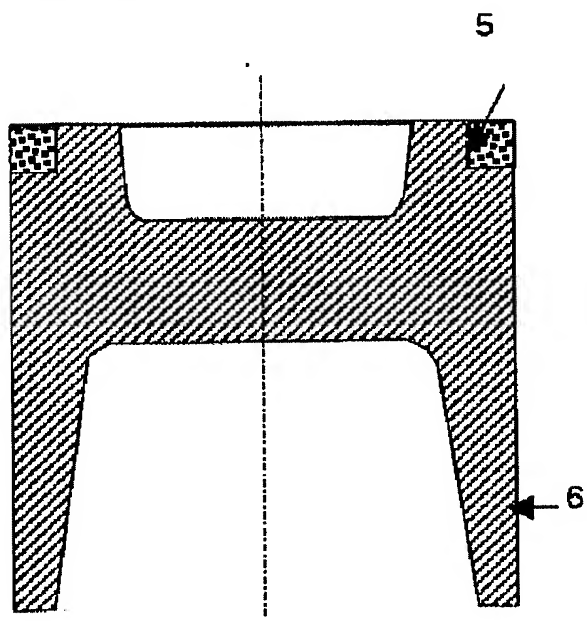
[Drawing 1]



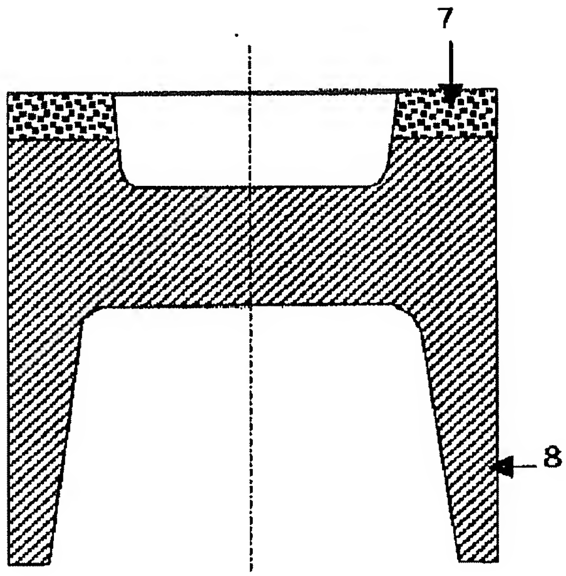
[Drawing 2]



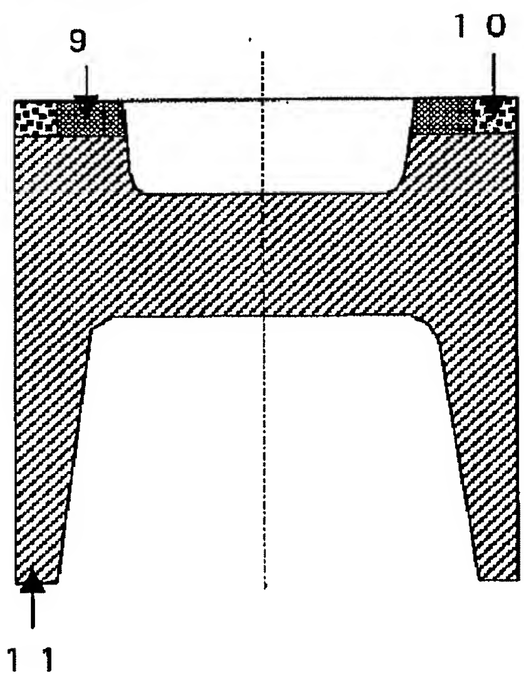
[Drawing 3]



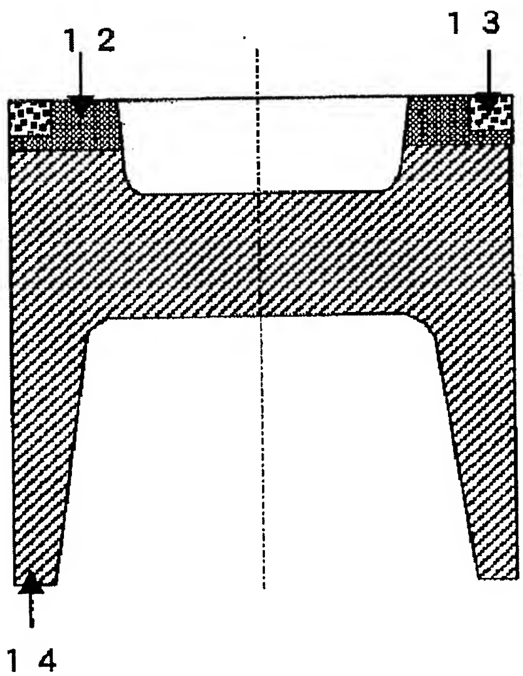
[Drawing 4]



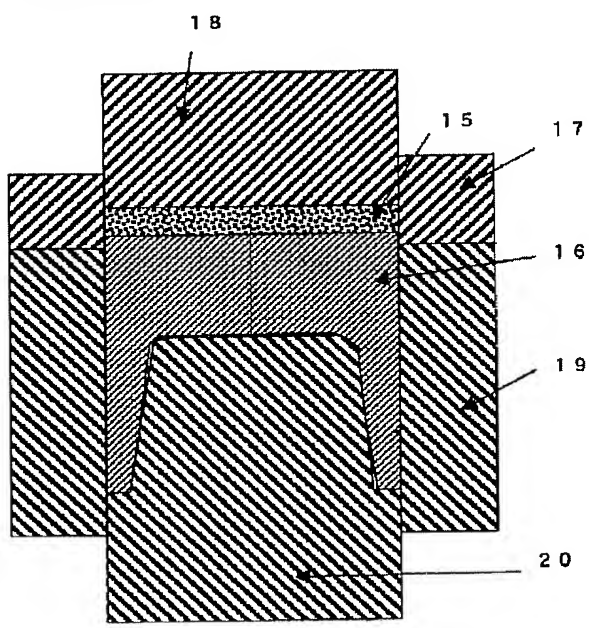
[Drawing 5]



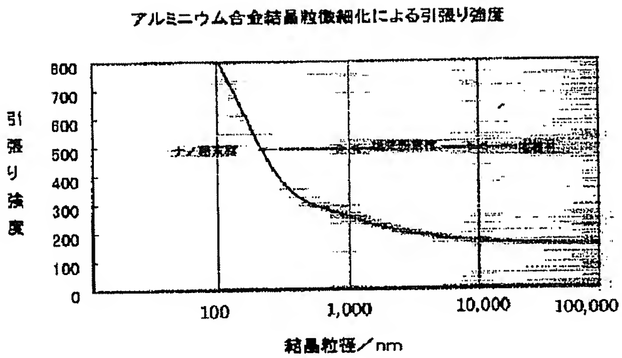
[Drawing 6]



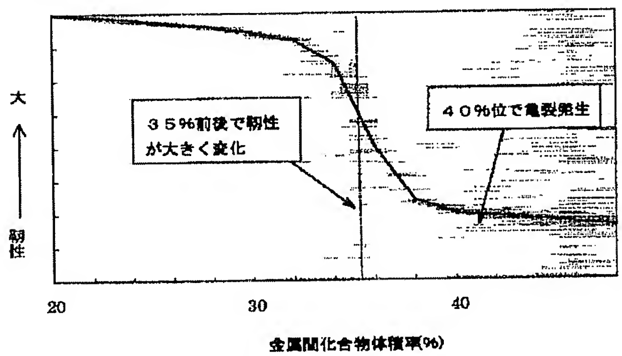
[Drawing 7]



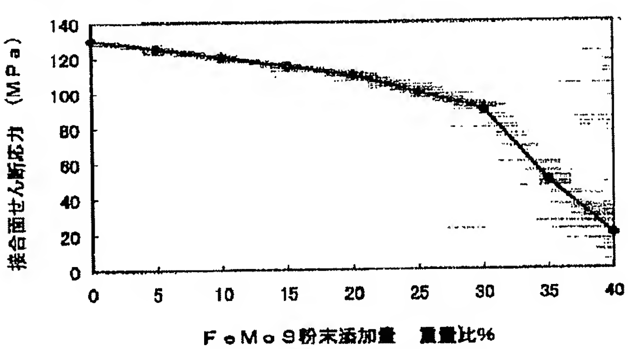
[Drawing 8]



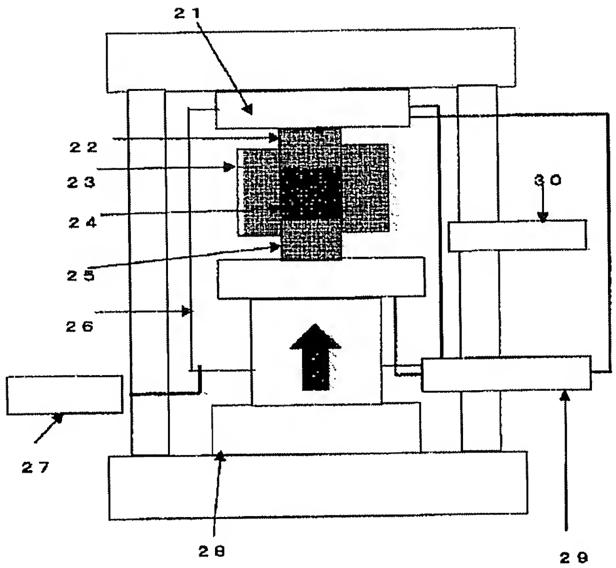
[Drawing 9]



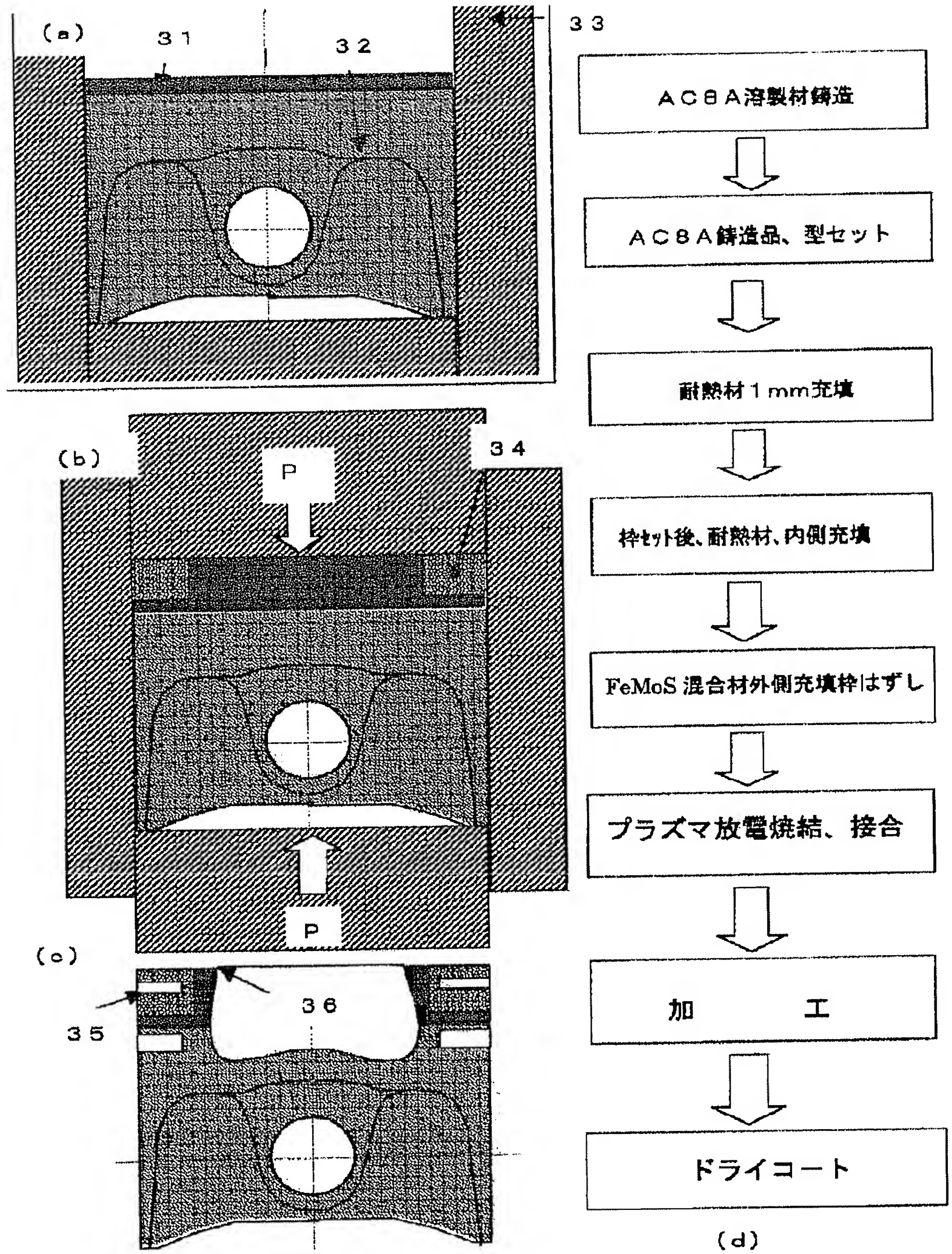
[Drawing 10]



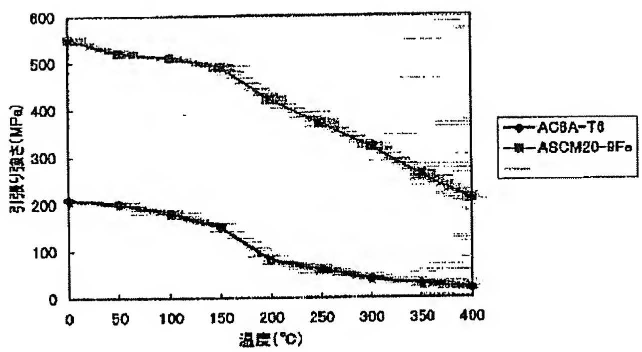
[Drawing 11]



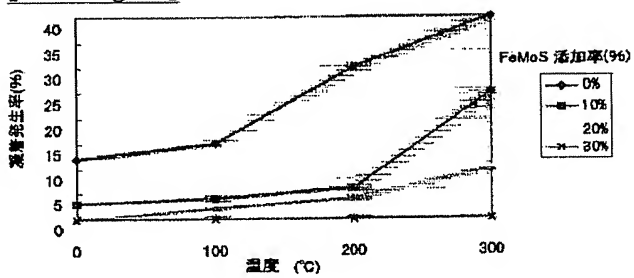
[Drawing 12]


(a)
31
32
33
(b)
34
P
P
(c)
35
36
ＡＣ８Ａ溶製材鋳造
ＡＣ８Ａ鋳造品、型セット
耐熱材１mm充填
枠セット後、耐熱材、内側充填
FeMoS 混合材外側充填枠はずし
プラズマ放電焼結、接合
加　工
ドライコート
(d)

[Drawing 13]



[Drawing 14]



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Ｂ２１Ｋ　1/18		Ｂ２１Ｋ　1/18	Ｚ　４Ｅ０８７
Ｂ２２Ｆ　3/105		Ｂ２２Ｆ　3/105	４Ｋ０１８
Ｆ０２Ｂ　23/06		Ｆ０２Ｂ　23/06	Ｈ
Ｆ０２Ｆ　3/00		Ｆ０２Ｆ　3/00	Ｇ

審査請求　未請求　請求項の数７　ＯＬ　（全 ８ 頁）　最終頁に続く

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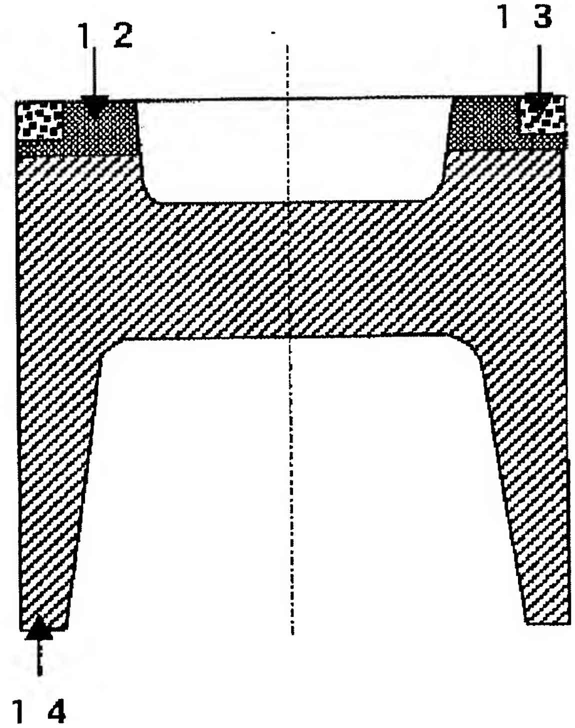
AE07
4E087 BA04 BA23 CB01 HA62
4K018 AA16 AB05 AC01 BA08 EA22
EA23 EA44 JA27 JA29 KA08

(54)【発明の名称】　高強度アルミニウム合金粉末材料とアルミニウム合金溶製材鋳造品の複合成型法

(57)【要約】
【課題】従来のアルミニウム合金動燃系部品は溶製材を鋳造、又は鋳鉄を一部鋳包んで製造している為、鋳鉄鋳包み品は重量が重く、母材との接合強度が弱い。
【解決手段】ＡＣ８Ａ溶製材で鋳造した鋳造品を型にセット後、必要な特性を備えた超微細結晶粒を持つ２種類のアルミニウム合金粉末を内、外周に充填後、プラズマ放電機により成形、同時に鋳造品との接合を行い、図６のように一体成形する。図６の部品は上部内周は燃焼の為、耐熱性、外周は摺動の為、耐摩性を必要とし、省エネの為、軽量化が求められている。１２は１４より、耐熱性にすぐれ、１３は１２に低フリクション材を混合した粉末材料で耐摩性に優れている。アルミニウム合金超微細結晶粒な為、軽量で強度が高く、成形性、母材との接合性に優れ、薄肉設計が可能である。



【特許請求の範囲】
【請求項１】図１、２、４のように構造体全体が２種類のアルミニウム合金で構成され、上１、３、７は粉末成形品、下２、４、８は溶製材鋳造品で構成され、下２、４、８を鋳造で成形後、型にセットして粉末を充填して熱間鍛造（プラズマ放電焼結含む）で２層に一体成形したことを特徴とした複合成形体。
【請求項２】図３のように構造体全体が２種類のアルミニウム合金で構成され、上部外５は粉末成形品構造体、上部内、下部６は溶製材鋳造品で構成され、６を鋳造で成形後、型にセットして粉末を外周に充填して熱間鍛造（プラズマ放電焼結含む）で２層に一体成形したことを特徴とした複合成形体。
【請求項３】図５、６のように構造体全体が３種類のアルミニウム合金で構成され、外１０、１３、内、下９、１２は粉末成形品構造体、下部１１、１４は溶製材鋳造品で構成され、下１１、１４を鋳造で成形後、型にセットして粉末を下１１、１４に１mm充填後境界の枠をとうして内、外２層にわけて充填して枠をはずした後、熱間鍛造（プラズマ放電焼結含む）で３層に一体成形したことを特徴とした複合成形体。
【請求項４】図４の上部、図３、５、６外周の材料は、Ｍｏ，Ｓ，Ｃの少なくとも一つの成分が入った粉末を内周の材料（図３は５、６の内周材）に混合した材料であることを特徴とする、請求項１、２、３記載の複合成形体。
【請求項５】燃焼が生じ、高温高負荷がかかる上部のアルミニウム合金粉末の成分として、Ｓｉ、Ｆｅ、Ｔｉ、Ｃｒ、Ｎｉ、Ｃｏ、Ｃｕ、Ｚｒの少なくとも、１種以上から構成されており、用途によって金属間化合物が１５％以上４０％とする、請求項１、２、３記載のアルミニウム合金粉末材料。
【請求項６】下部の材料は、上部より負荷、温度共低いので金属間化合物が２０％以下で比重が請求項５より軽い材料であることを特徴とする、請求項１、２、３、４記載のアルミニウム合金溶製材料。
【請求項７】プラズマ放電焼結機で部品上部の焼結（図７の１５）、下部部品（図７の１６）との接合、又は鋳造、鍛造成形材同志の接合する場合において、材料の特性又は、部品の形状で、昇温、加圧時に変形が危惧される場合は、焼結（図７の１５）、接合部のみ必要な温度に効率良く昇温し、他の部分（図７の１６）は変形しないような温度に維持する為、(イ)焼結又は接合する近傍の金型（図７の１７，１８）には、熱伝導率が小さく、固有抵抗が大きい金型材料を、それ以外の金型（図７の１９、２０）は、熱伝導率が大きく、固有抵抗が小さい材料金型を使用する。
(ロ)同一材料、又は異種材料で昇温又は接合する近傍の金型は容積を小さくして、昇温しやすくし、他の部分は変形しないよう温度を下げる為、、金型容積を大きくする。
(ハ)(イ)、(ロ)共、焼結又接合する近傍の金型には、ヒーターなどの加熱装置、それ以外の金型には、温度が上がらないよう冷却装置を設け、温度調整する。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、高強度アルミニウム合金粉末材料とアルミニウム合金溶製材鋳造品の複合成型法に関する。
【０００２】
【従来の技術】(イ)燃焼温度が高く、温度が２００～４００℃のあがる動燃部品構造体は燃焼部が近い上部はニレジスト鋳鉄から成る耐熱性の補強部材を本体とは別体に作製しておき、このような補強部材を摩擦圧接の方法によってアルミニウム合金から成る本体上部に結合固着する。このときに本体の上部に設けられている周溝を補強部材によって閉塞することにより冷却用空洞を形成する。（例えば、特公平６－２６１３参照）
【０００３】
【発明が解決しようとする課題】従来の高温動燃部品構造体は上部をニレジスト鋳鉄で構成している為、表１のように重量が重く、Ｆｅ，Ｎｉ系材料の為、トップリング溝部の冷却効率も悪い。又接合部にＦｅが多く含んだ脆い金属間化合物が生成され接合強度が弱い。又ニレジスト鋳鉄はアルミニウム合金に比べ切削性が悪い。
【表１】

	ニレジスト鋳鉄	アルミニウム合金粉末成形体
比重（g／cm2）	７．４	２．８～３．２
熱伝導率(W／m・℃)	３２	８０～１４０

【０００４】
【課題を解決するための手段】上記の問題点を解決するために、(イ)高強度と高靭性を両立させるため、図８のように超急冷による組織の微細化と図９のように金属間化合物の体積率制御によって強度・靭性を両立させる。これにより薄肉軽量化が可能になる。構造体の外周を、上記の粉末に低フリクション粉末を混合して一体成形することにより、耐摩環、アルマイト処理がいらなくなりコストが低減でき、リードタイムも短縮できる。
【０００５】
【発明実施の形態】本発明は構造体の一部にアルミウム合金粉末材をもちい、用途におうじて、部位別に、粉末の種類を変えアルミニウム合金溶製材鋳造品に充填、成形したものである。
【０００６】上記の高温動燃部品上部（燃焼部が近い）の材料は、高温疲労強度が必要なため、金属間化合物は

１５%以上４０%以下が望ましい。４０%以上になると図９のように脆くなり、ワレが生ずる危険性が高い。

【０００７】上記０００６アルミニウム合金材の結晶粒は、強度、成形性の面から粉末生成時に急冷して図８のように結晶粒を細かくしたほうが良い。具体的には超塑性変形が可能な結晶粒１μ以下が望ましい。

【０００８】上記０００６～０００７の粉末材料成形は、伸びがもっとも出る温度に維持して成形するのが望ましい。

【０００９】０００６、０００７の低フリクション材は材料の強度低下、上下接合するものについては図１０のように接合力の低下を招くので、重量比で３０%以下が望ましい。下部形状が弱く、変形不可なため加圧力が３０ｋｇ／mm2以下で温度は、上下材料で融点の低い方の再結晶温度（融点の０．７位）で熱間鍛造、拡散接合又は図１１のように放電プラズマ焼結、接合させる。熱間鍛造、拡散接合よりプラズマ放電焼結、接合のほうが接合界面間隙にプラズマが発生し、温度が界面に集中的に上がるため、他の形状部を変形させることなく、低圧力で成形、接合できるので望ましい。

【００１０】上記接合材料は結晶粒が小さい程、又アルミの酸化皮膜を還元するＭｇ含まれているのがよい。具体的には結晶粒は超塑性変形が可能な１μ以下、Ｍｇは０．５～４%が望ましい。

【００１１】

【実施例】実施例について図面を参照して説明すると、図１２のｃは直憤ディーゼルピストンの完成図で外径６０ｍｍ、高さ６０ｍｍ、重量２５０ｇである。ピストン上部はアルミニウム合金粉末成形体でトップリング溝下２ｍｍから上側の形状を構成し、トップリング溝奥１ｍｍのところで内３１、外３４で、又接合面から上１ｍｍのところで材質を３４にかえてある。内側３１粉末材料成分は、(1-1)Ａｌ（残）＋Ｓｉ（２０%）＋Ｆｅ（９%）＋Ｃｕ（３%）＋Ｍｇ（１%）で、(1-2)外側３４は内側の粉末にＦｅＭｏＳの粉末を重量比で３０%混合したもので、平均結晶粒は１μｍである。上記材料を使用した理由は、リップ部３６は３５０℃前後での高温強度が必要な為、図１２のように、高温強度の高い(1-1)の超微粒粉末をもちい、３５のトップリング溝は３００℃前後での耐凝着性が必要なため、図１４のように、ＦｅＭｏＳの粉を添加した材料をもちいた。又、下面１ｍｍは外側３４のＦｅＭｏＳが下部鋳造品３２と接合しにくいので、ＦｅＭｏＳを含まない内３１の材料で構成した。ＦｅＭｏＳ比重が重いため、最小限必要な部分にとどめた。３２をＡＣ８Ａ溶製材にしたのは、この部分は３１、３４に比べ温度、負荷共低いため、ＡＣ８Ａ材で強度が確保でき、又材料費も１／３以下な為、コストをさげるため、粉末の使用は最小限にとどめた。図１２の（ｄ）は工程図で型にＡＣ８Ａ鋳造品３２をセットして(1-1)の粉を１ｍｍ充填後、境界をもうけ、(1-2)、(1-1)を外、内に充填して、境界をはずす。図１１のプラズマ放電焼結機に型をセットして４７０℃の温度で１００ＭＰａの圧力で上部粉末を成形すると同時に下部３２と接合させる。

【００１２】

【発明の効果】本発明は以上説明したような形態で実施され、以下に記載されるような効果を奏する。

【００１３】微細な結晶粒の粉末成形材の為、図１３のように従来のＡＣ８Ａ溶製材より、材料、又温度によって強度が２～５倍高い為、薄肉設計が可能になり、３０～６０%軽量化（溶製材鋳造品上部比）ができる。

【００１４】図１２直憤ディーゼルピストンにおいて従来は燃焼室リップ部３６が結晶粒の大きいＡＣ８Ａ溶製材でできているので、３５０℃前後の高温で高温疲労の為、ヒビ割れが生じたが、図１３のようにＦｅ等の高温成分を添加して、金属間化合物を３０%程度生成した微細な結晶粒粉末成形体なため、高温疲労強度が高く、ヒビ割れない。

【００１５】従来のディーゼルピストン冠面部はニレジスト鋳鉄耐摩環を摩擦圧接で母材と接合していたため、接合部の金属間化合物が脆く、接合強度が弱い。本発明品はアルミ合金同志の接合で固相接合（摩擦圧接除く）なため、接合部に金属間化合物ができにくく、接合強度が高い。その為、トップリングハイトの短縮が可能になる。（トップリングハイトの短縮は燃費向上に効果がある）

【００１６】従来のガソリンピストンは用途により、トップリング溝に加工完了後アルマイト処理をして焼き付きを防止している。本発明は外側に低フリクションのＦｅＭｏＳを混合した粉で成形しているため、アルマイト処理が不要である。

【図面の簡単な説明】

【図１】請求項１の複合成型体を示す縦断面図である。

【図２】請求項１の複合成型体を示す縦断面図である。

【図３】請求項２、４の複合成型体を示す縦断面図である。

【図４】請求項１、４の複合成型体を示す縦断面図である。

【図５】請求項３、４の複合成型体を示す縦断面図である。

【図６】請求項３、４の複合成型体を示す縦断面図である。

【図７】請求項１～６の成形法を示す縦断面図である。

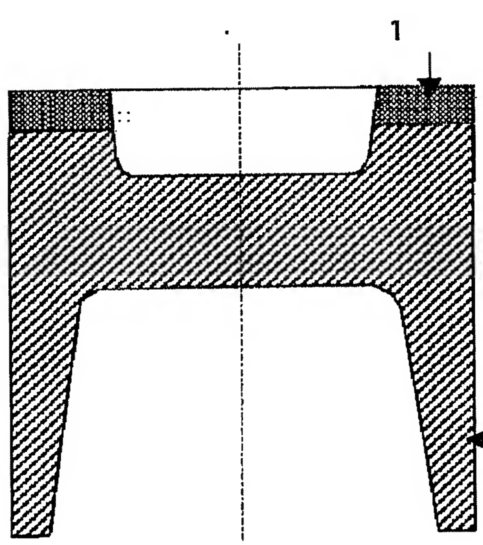
【図８】アルミニウム合金結晶粒微細化による引張り強度を表したグラフである

【図９】アルミニウム合金粉末中の金属間化合物の量と鍛造成形体の靭性の関係グラフである。

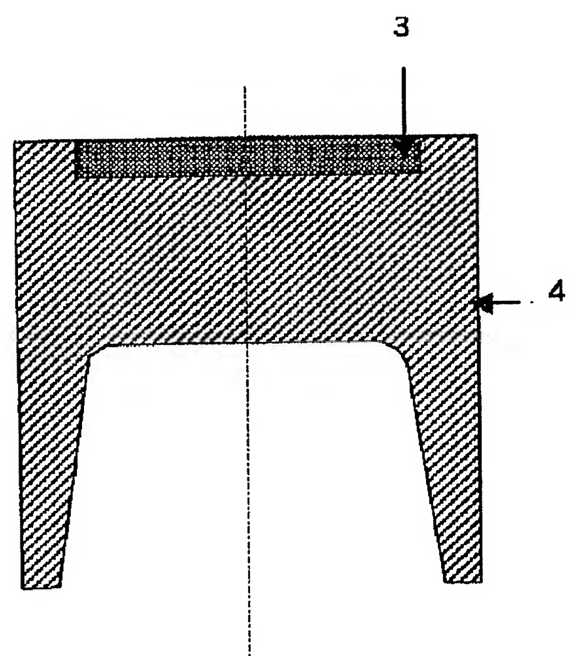
【図１０】アルミニウム合金粉末（Ａｌ－２０Ｓｉ－３Ｃｕ－１Ｍｇ－９Ｆｅ）とＦｅＭｏＳ粉末の混合鍛造成形体とＡＣ８Ａ材のプラズマ放電接合部のせん断応力の

関係グラフである。
【図１１】プラズマ放電接合の概略図である
【図１２】請求項６の内燃機関ピストン粗材成形工程を示した図でａはＡＣ８Ａ鋳造品を型にセットして耐熱粉末を充填、ｂは枠をつけて内、耐熱材、外、耐摩材を充填後プラズマ放電により高速超塑性加工、ｃは加工後の形状、ｄは工程図である。
【図１３】ＡＣ８Ａ溶製材、Ａｌ－２０Ｓｉ－３Ｃｕ－１Ｍｇ－９Ｆｅ粉末合金成形体の高温引張り強度の関係グラフである。
【図１４】Ａｌ－２０Ｓｉ－３Ｃｕ－１Ｍｇ－９Ｆｅ合金のＦｅＭｏＳ合金粉末を混合した）鍛造成形体の凝着試験における、ＦｅＭｏＳ量と凝着発生温度の関係グラフである。
【符号の説明】
１、３、９、１２　耐熱アルミニウム合金粉末成形体
２、４、６、８、１１、１４　ＡＣ８Ａ溶製材鋳造品
１３　１、３、９、１２に低フリクション材を混合した耐摩性、耐凝着性にすぐれたアルミニウム合金粉末成形体
１５　耐熱アルミニウム合金粉末
１６　アルミニウム合金溶製材鋳造品
１７、１８　熱伝導率が小さく、固有抵抗が大きい金型材料
１９、２０　１７、１８より熱伝導率が大きく、児湯抵抗が小さい金型材料
２１　上部電極
２２　上部パンチ
２３　型
２４　サンプル
２５　下部パンチ
２６　真空室
２７　真空ポンプ
２８　油圧ユニット
２９　パルス電気エネルギー
３０　熱制御系
３１　耐熱アルミニウム合金粉末成形体
３２　ＡＣ８Ａ溶製材ピストン下部鋳造成形体
３３　金型
３４　２９材料にＦｅＭｏＳ粉末を３０％添加混合した粉末材料
３５　直噴ディーゼルピストントップリング溝
３６　直噴ディーゼルピストンリップ部

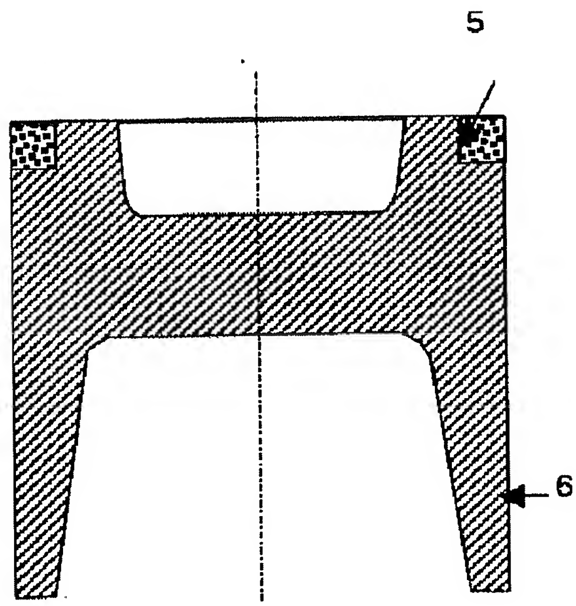
【図１】



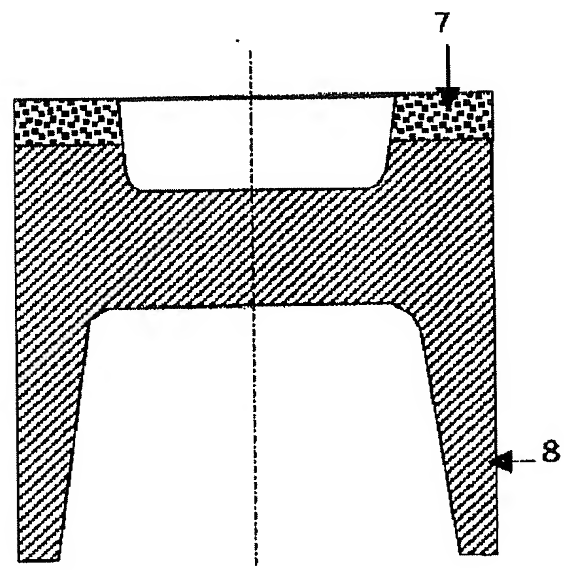
【図２】



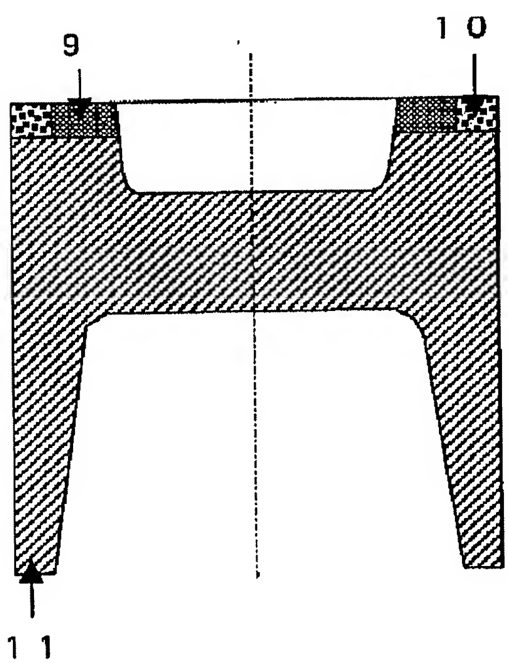
【図３】



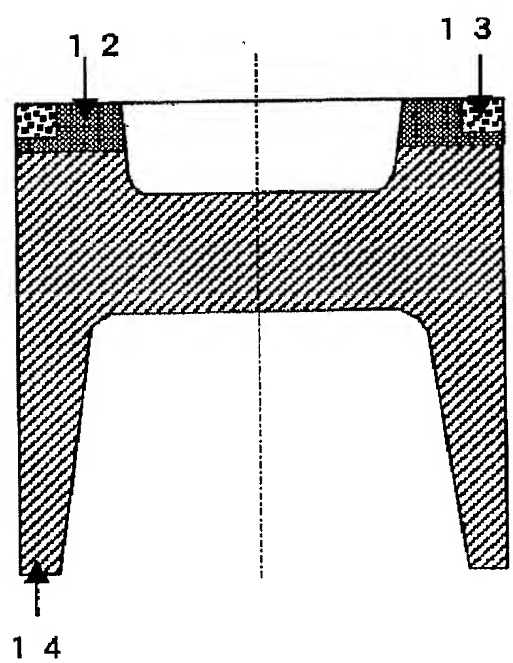
【図４】



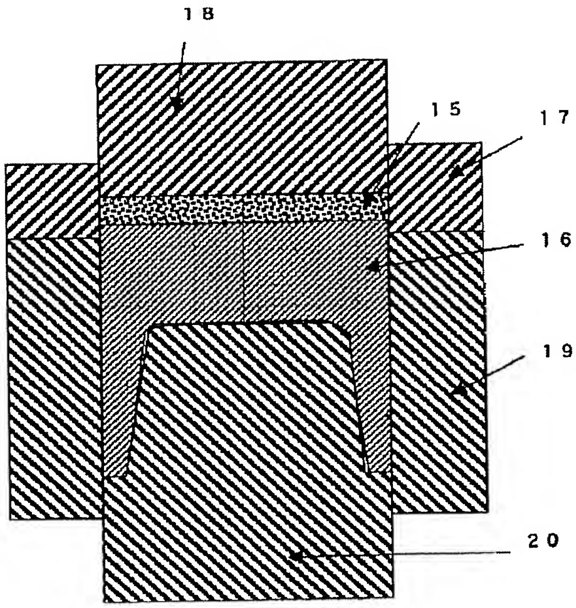
【図５】



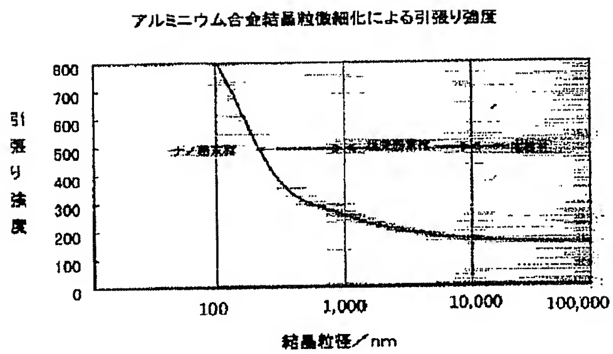
【図６】



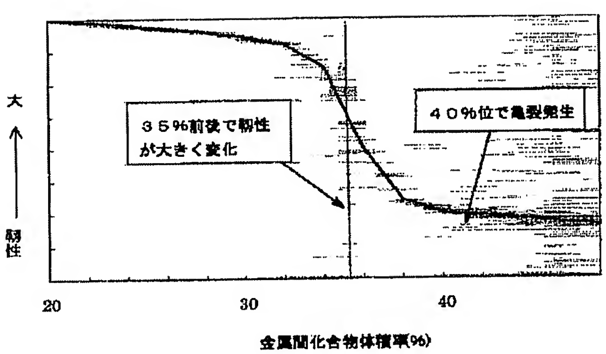
【図７】



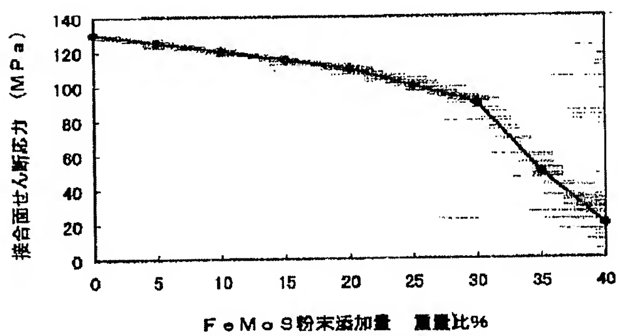
【図８】



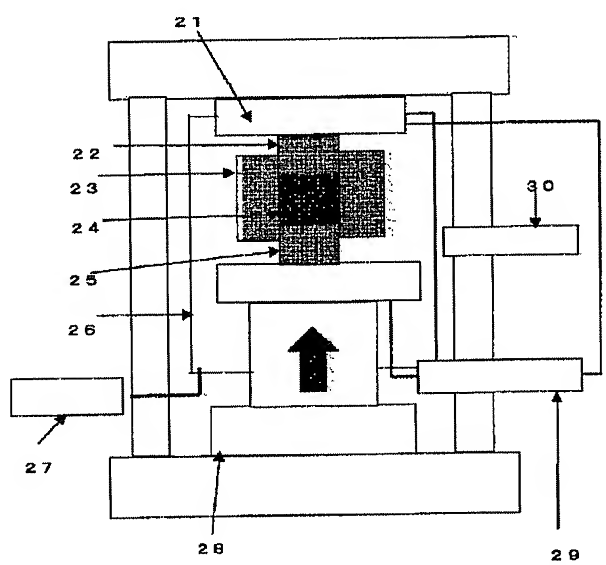
【図９】



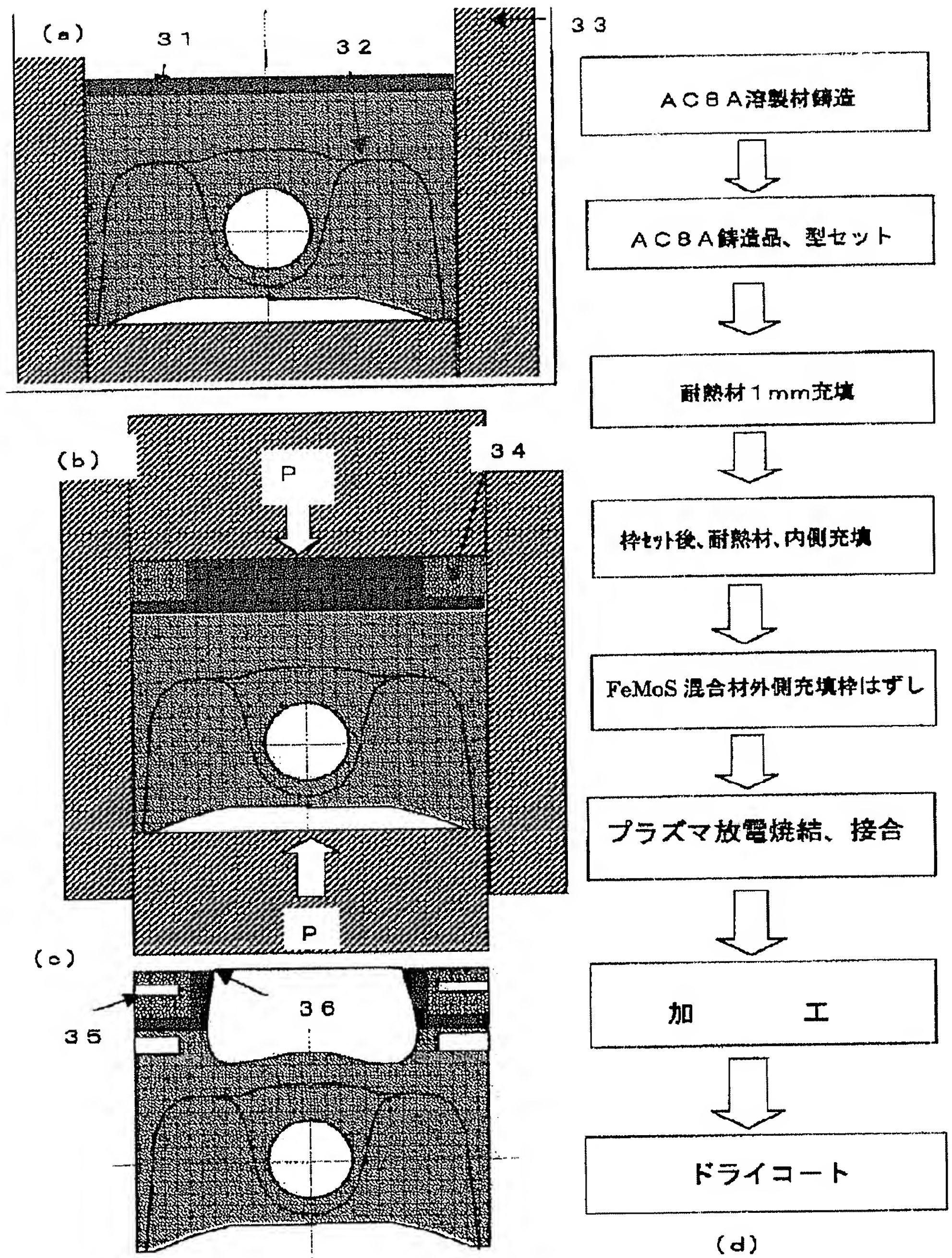
【図１０】



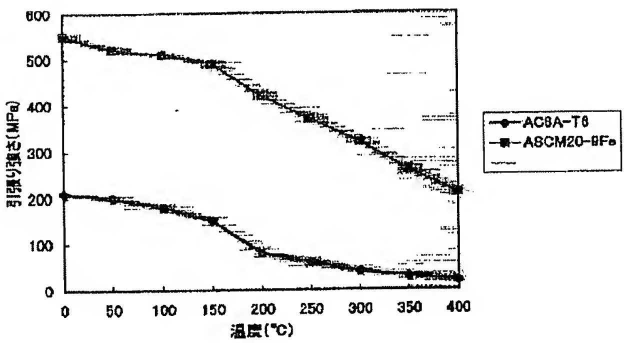
【図１１】



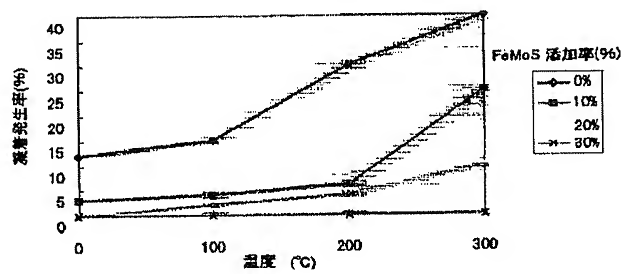
【図１２】


(a)
３１
３２
３３
(b)
３４
P
P
(c)
３５
３６
ＡＣ８Ａ溶製材鋳造
ＡＣ８Ａ鋳造品、型セット
耐熱材１mm充填
枠ｾｯﾄ後、耐熱材、内側充填
FeMoS 混合材外側充填枠はずし
プラズマ放電焼結、接合
加　　工
ドライコート
(d)

【図１３】



【図１４】



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